

REMARKS

The Office Action of April 10, 2007, has been carefully considered. Claims 1-24 were originally pending in the application. Claims 13, 15 and 16 have been cancelled. Claims 1-12, 14, and 17-19 have been amended. Claims 1-12, 14 and 17-24 are now pending. Each of the objections and rejections in the Office Action are addressed in the following remarks. In view of the following remarks, Applicant respectfully requests reconsideration and allowance of the subject application.

Informal Objections

Claim 19 is objected to because the phrase “has been accessed” in lines 21 and 22-23 should read “have been accessed.” Applicant has corrected the phrase in claim 19 in accordance with the examiners suggestions.

Claim Rejections Under 35 USC §101

Claims 1 – 11 were rejected under 35 USC §101 as being directed to non-statutory subject matter for not being limited to tangible embodiments. Claim 1 and claims 2-11 have been amended to recite “A computer readable medium apparatus ... ” to more clearly recite a tangible embodiment. Therefore, the Applicant respectfully submits that the §101 rejection of amended Claims 1-11 is moot, and respectfully requests reconsideration and withdrawal of this rejection.

Claim Rejections Under 35 USC §102(b)

Claims 12-17 were rejected under 35 U.S.C. §102(b) as being anticipated by U.S. Patent 6,308,185 to Garup. (hereinafter referred to as the “Garup” reference).

In overview, in order for prior art to anticipate a claim under 35 U.S.C. §102 every element of the claimed invention *must be identically disclosed* either expressly or under principles of inherency in a single reference. Further, the exclusion of a claimed element from a prior art reference, no matter how insubstantial, is enough to negate anticipation by that reference. The test of whether anticipation exists in a particular case is a question of fact, and is applied element-by-element to a single prior art reference. Only if the prior art literally reads on every element of the rejected claim will the claimed invention be anticipated under this test.

With this in mind, the Applicant analyzes the §102 rejection of the claims in the present application.

Claim 12 has been amended to clarify the elements that are not taught or suggested by the Garup. For convenience, amended Claim 12 is reproduced below with portions in bold to better emphasize some of the elements that are not taught or suggested in the prior art of record.

12. A method for executing statements within a program to support ephemeral garbage collection, the method comprising:

specifying a range of card table memory to watch during program execution by calling a **write-watch mechanism that performs tracking of the access to the card table memory and maintains a write-watch list that identifies cards accessed within the card table memory since a garbage collection process was last performed**, the card table memory identifying prior access to a plurality of cards, each card being associated with and updated upon

access to one or more objects allocated within a memory heap, the memory heap being divided into the plurality of cards with each card being grouped into one of a plurality of bundles, wherein one of the plurality of bundles corresponds to a subset of that plurality of cards that are tracked using a page of card table memory;

creating one or more bundle tables identifying groupings of the cards in the plurality of bundles;

for each store statement within the program, storing a value at a memory location within the heap memory based on the store statement, marking one of the plurality of cards within the card table memory based on the memory location, and tracking access to the card table memory;

updating at least one bundle table by marking the bundle table based on information obtained from the write-watch list, wherein the updated marked bundle table corresponds to marked cards having associated objects that have been accessed since a last garbage collection process;

for each marked bundle table, determining at least one marked card within the marked bundle table;

for each marked card, determining at least one accessed object within the marked card; and

performing garbage collection upon the at least one accessed object.

The Examiner contends that the Garup reference anticipates Claim 12. As shown above, amended independent Claim 12 recites “creating one or more bundle tables identifying groupings of the cards in the plurality of bundles” and “updating at least one bundle table by marking the bundle table based on information obtained from the write-watch list, wherein the updated marked bundle table corresponds to marked cards having associated objects that have been accessed since a last garbage collection process”. A store process is performed whenever a store operation is encountered during a program’s execution. At some point, a garbage collection process is requested to free up some memory. Amended Claim 12 is directed at the store process. Thus, as further described in applicant’s specification,

applicant creates a card table (404) of cards that are tracked, a bundle table 406 (that identifies groupings of the cards in the plurality of bundles) and write-watch info. (408) (generated with the write-watch mechanism that contains a list of cards that have been accessed since the last garbage collection process). Applicant then updates the bundle table by marking the bundle table based on information obtained from the write watch list. Applicant then determines marked cards and performs garbage collection. Garup does not does not teach creating an updated bundle table by marking the table based on information obtained from a write-watch list. Thus Garup does not teach or suggest amended Claim 12. Therefore, the Applicant respectfully submits that the §102 rejection of amended Claim 12 is improper, and respectfully requests reconsideration and withdrawal of this rejection.

Claims 14, 17 and 18 depend from independent Claim 12 and are allowable as depending from an allowable base claim as discussed above. These claims are also allowable for their own recited features which, in combination with those recited in Claim 12, are neither shown nor suggested by the Garup reference. Therefore, the Applicant respectfully submits that the §102 rejection of Claims 14, 17 and 18 is improper, and respectfully requests reconsideration and withdrawal of this rejection.

Claim Rejections Under 35 USC §103

Claims 1-11, and 18-24 were rejected under 35 U.S.C. §103 as being anticipated by Garup in view of U.S. patent number 6,148,309 to Azagury et al. (hereinafter “Azagury”)

Claim 1 has been amended to clarify the elements that are not disclosed by the Grarup reference. For convenience, amended Claim 1 is reproduced below with portions in bold to better emphasize some of the elements that are not disclosed in the Grarup reference.

1. A computer-readable medium apparatus having computer-executable instructions for performing ephemeral garbage collection, the computer-readable medium apparatus being accessible by a computing device, the instructions comprising:

requesting a list from a tracking mechanism, **the list identifying a plurality of memory locations that have been accessed since the last ephemeral garbage collection**, each memory location corresponding to one of a plurality of cards associated with a card table, wherein the card table identifies one or more cards with one or more objects that have been accessed, each card being associated with the one or more objects allocated from within a memory heap;

creating a bundle table identifying a plurality of bundles, wherein each bundle identifies groupings of subsets of the plurality of cards;

updating bundles by marking two or more of the plurality of bundles in the table using the list, wherein the updated marked bundle corresponds to marked cards in the marked bundle having associated objects that have been accessed since a last garbage collection process;

for each marked bundle in the bundle table, determining at least one marked card within the marked bundle;

for each marked card, determining at least one accessed object within the marked card; and

performing garbage collection upon the at least one accessed object. (Emphasis Added)

As shown above, amended independent Claim 1 recites “requesting a list from a tracking mechanism, **the list identifying a plurality of memory locations that have been accessed since the last ephemeral garbage collection**”, and “**creating a bundle table identifying a plurality of bundles, wherein each bundle identifies groupings of subsets of the plurality of cards; updating bundles by**

marking two or more of the plurality of bundles in the table using the list”.

As described in the specification of the present application, the present technique tracks memory access to cards, the indications of which are reflected in a card table. Applicant also creates a bundle table 406 that identifies multiple groupings of the cards in the plurality of bundles and generates a separate list of multiple cards that have been accessed since the last garbage collection process. Then, when garbage collection is requested, applicant uses this list to mark multiple bundles in the table. Thus, as further described in the specification, by using the list to mark the bundles in the table, the present technique does not have the performance overhead of re-reading cards (e.g. or a time stamp associated with the card). This technique allows garbage collection to utilize existing code and operate efficiently regardless of the heap size.

Neither the Grarup reference nor the Azagury reference disclose: 1) a bundle table that has multiple entries that indicate multiple groupings of the cards, and 2) a separate list of multiple cards that have been accessed since the last garbage collection. Nor do the references use multiple entries in the list to update and mark multiple bundle entries in the table. As stated in the office action, Grarup does not expressly disclose identifying (or updating) a marked bundle based on the list. Azagury discloses a single time stamp for each car (Column 4, lines 35-42). Azagury also discloses scanning cards for newer time stamps (Column 4, lines 45-48), where the applicant’s technique does not scan for newer time stamps but rather updates a bundle table from the list of multiple cards that have been accessed since the last garbage collection, thereby reducing overhead. Applicant’s garbage collection process uses multiple entries in the list to update multiple marked entries which are then used to then identify cards. This process of updating and identifying

bundles, as recited in amended claim 1 is not present in the Grarup or Azagury reference. For at least the reasons discussed above, amended Claim 1 is allowable in view of the Grarup and Azagury reference.

Claims 2-11 depend from Claim 1 and are allowable as depending from an allowable base claim. These claims are also allowable for their own recited features which, in combination with those recited in Claim 1, are neither shown nor suggested by the Grarup reference. For at least the reasons, Claims 2-11 are allowable. Therefore, the Applicant respectfully submits that the §102 rejection of Claim 2-11 is improper, and respectfully requests reconsideration and withdrawal of this rejection.

Claim 19 has been amended to clarify the elements that are not disclosed by the Grarup reference. For convenience, Claim 19 is reproduced below with portions in bold to better emphasize some of the elements that are not disclosed in the Grarup reference.

19. A system for performing ephemeral garbage collection, the system comprising:

a processor; and

a memory into which a plurality of instructions are loaded and into which a plurality of objects are dynamically allocated, the memory having a heap into which the objects are allocated, the heap being divided into a plurality of cards which are grouped into a plurality of bundles, each card being associated with one or more of the plurality of objects; wherein upon execution of the plurality of instructions by the processor, the system being configured to:

request a list from a tracking mechanism, the list only identifying memory locations that have been written into since a last garbage collection cycle, each memory location corresponding to one of the plurality of cards associated with a card table, wherein the card table identifies one or more cards that have been accessed;

creating one or more bundle tables wherein each bundle table identifies groupings of the plurality of cards in the plurality of bundles;

identify updating at least one marked bundle table by marking bundles within the bundle table based on the list, wherein the marked bundles corresponds to marked cards that represents a subset of the plurality of cards having associated objects that have been accessed since a last garbage collection process;

determine, for each marked bundle within the bundle table, at least one marked card within the marked bundle, the at least one marked card indicating that one or more objects associated with the marked card has been accessed;

determine, for each marked card, the one or more objects that has have been accessed; and

perform garbage collection upon the one or more accessed objects. (Emphasis added)

The Examiner contends that the Garup in view of the Azagury reference renders Claim 19 obvious. Claim 19 has been amended in a similar manner as Claim 1. Further Claim 19 recites “request a list from a tracking mechanism, the list only identifying memory locations that have been written into since a last garbage collection cycle” Neither of the references only provide a list of only the memory locations that have been written into since the last garbage collection cycle. Specifically Azagury provides a timestamp for every remembered set for each car. Not having to provide a timestamp for every remembered set reduces processing overhead. Accordingly, for all of the reasons discussed above with regards to Claim 19, this claim is allowable.

Claims 20-24 depend from independent Claim 19, and are allowable as depending from an allowable base claim as discussed above. These claims are also allowable for their own recited features which, in combination with those recited in their respective independent claims, are neither shown nor suggested by the Garup reference alone or with any permissible combination of the prior art of record.


Therefore, the Applicant respectfully submits that the §103 rejections of amended Claims 20-24 is improper, and respectfully requests reconsideration and withdrawal of this rejection.

Conclusion

Applicant has considered the other references cited by the Examiner in the Office Action. None of these references appear to affect the patentability of Applicant's claims. By the foregoing remarks, Applicant believes that all pending Claims 1-12, 14 and 17-24 are allowable and the application is in condition for allowance. Therefore, a Notice of Allowance is respectfully requested. Should the Examiner have any further issues regarding this application, the Examiner is requested to contact the undersigned attorney for the Applicant at the telephone number provided below.

Respectfully Submitted,

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